DESIGN AND ANALYSIS OF PLANAR MICROSTRIP ANTENNAS FOR 5G AND IoT APPLICATIONS

SHORT SYNOPSIS

Submitted in partial fulfilment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Manav Rachna International Institute of Research and Studies
(Deemed to be University)

by

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CERTIFICATE

I hereby declare that the short synopsis "Design and Analysis of Planar Microstrip Antennas for 5G and IoT Applications" is being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Electronics & Communication Engineering under the faculty of Engineering & Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2022-2023. It is a bonafide record of original work carried out under the supervision of Dr. Jyoti Verma. The work has not been submitted in full or part to any other university or institute for a degree or diploma. Further, it is certified that short synopsis is plagiarism-free and the proof has been submitted.

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ABSTRACT

The evolution of Fifth-Generation (5G) networks is readily available as the main driver of the growth of the Internet of Things (IoT) applications. The Internet of Things is a new idea that interconnected gadgets for variety of applications, including communication, transportation, medical science, education, and commercial progress.

The most critical element of constantly developing wireless technology is an antenna and planar antennas are typically preferred in wireless applications due to their uniformity to planar and non-planar surfaces, ease of fabrication utilizing existing printed circuit technologies, mechanical toughness when mounted on stiff surfaces, and compatibility with Microwave Monolithic integrated circuits designs. Wireless communication is exploring every aspect, so the radio frequency spectrum is getting crowded due to the increasing demand for wireless applications. Furthermore, all modern future fifth-generation wireless systems require the integration of short-range transceivers such as Sub-6GHz, Sub-7GHz, WiFi-6, and WiFi-6E in a single computing device. This scenario has created a demand for 5G antennas for wireless networks. So, there is requirement to develop antennas with high gain, and wide bandwidth for wireless 5G transmission. Therefore, Federal Communications Commission is reallocating the spectrum for various wireless applications.

The main focus of this work is to design and develop 5G antennas that can handle several wireless protocols with higher bandwidth to meet future 5G applications. Various defective ground structures, parasitic patches, meandering edges, electromagnetic band gap structures, and notches will be added to the framework to decrease the dimensions. Various antenna performance parameters such as s-parameters, voltage standing wave ratio, Radiation, Beamwidth, Gain, and so on must be recorded and studied using an antenna simulation program.

Keywords: Internet of Things (IoT), Fifth Generation (5G), Wireless Local Area Network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), Multi-input multi-output (MIMO).

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1. INTRODUCTION

In modern life, using artificial brains has become more popular than the human brain. A modern wireless communication system is built on technologies such as second-generation, third-generation, fourth-generation, fifth-generation, and other applications. To meet today's needs, antennas with modern specifications such as small shape, cost-effectiveness, multiband operations, and so on are becoming increasingly important. An antenna is a transducer capable of converting one form of electromagnetic energy into another form of electromagnetic wave. The antenna serves as a link between a transmission line and space. It can be either directional or non-directional. Figure 1 depicts a wireless communication system in which signals travel through an electromagnetic wave between the transmitting and receiving antennas.

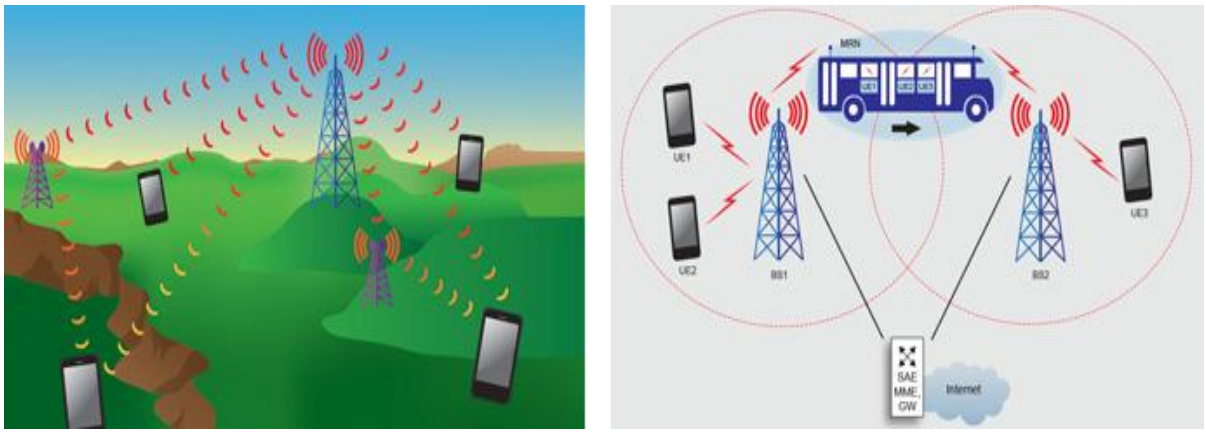

Figure1. Wireless communication system (Chowdhury, Shahjalal, Hasan, and Jang,2019)

In recent years, various technologies like Wi-Fi, Bluetooth, Wireless Local Area Networks, Worldwide Interoperability for Microwave Access, Long Term Evolution, and Ultra-Wide Bandwidth registered considerable growth, with a range of applications in the day-to-day life of human beings (Raut, Shevada, Malekar, and Kumar, 2021). An antenna is an essential part of any wireless communication system used for transmitting and receiving electromagnetic waves. The design and performance of the antenna system govern the overall performance of the wireless communication system. Figure 2 (a &b) shows explained 5G evolution in a systematic manner.

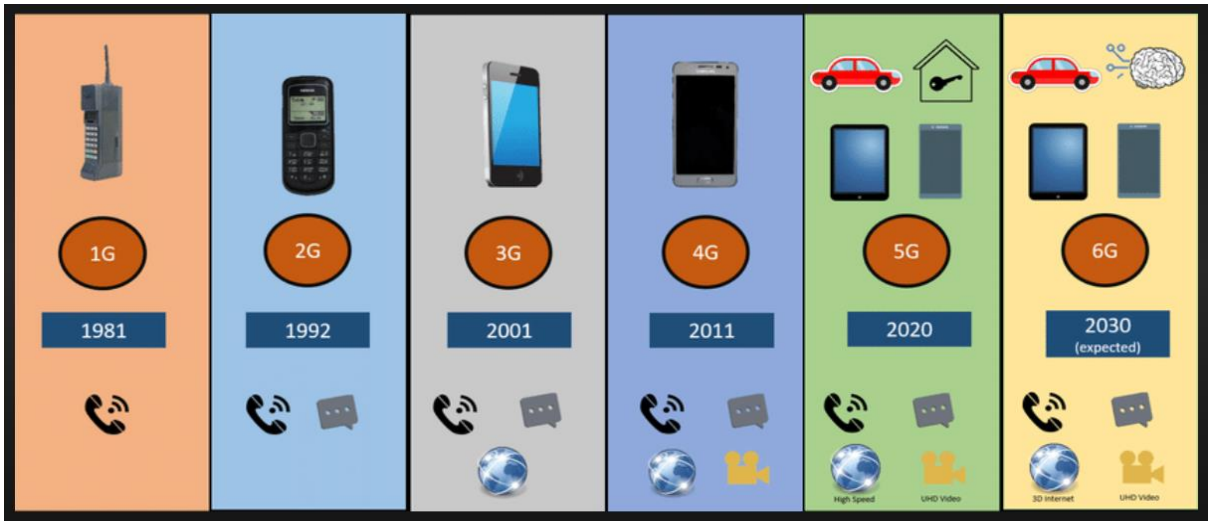

Figure 2(a). Evolution of 5G communication system (Tseng, Cho, and Wu, 2019)

	1G	2G	3G	4G	5G
Period	1980 – 1990	1990 – 2000	2000 – 2010	2010 – (2020)	(2020 - 2030)
Bandwidth	150/900MHz	900MHz	100MHz	100MHz	1000x BW pr unit area
Frequency	Analog signal (30 KHz)	1.8GHz (digital)	1.6 – 2.0 GHz	2 – 8 GHz	3 – 300 GHz
Data rate	2kbps	64kbps	144kbps – 2Mbps	100Mbps – 1Gbps	1Gbps <
Characteristic	First wireless communicatio n	Digital	Digital broadband, increased speed	High speed, all IP	
Technology	Analog cellular	Digital cellular (GSM)	CDMA, UMTS, EDGE	LTE, WiFi	WWWW

Figure 2(b). Comparison of various generations (Attaran, 2021)

Benefits of 5G over other previous techniques:

- Transmission speeds in 5G technology can achieve up to 20 Gbps. With this high speed, data access, programs, and distant applications are directly downloaded without waiting. Because computation may be done in the Cloud, so all devices will require less internal memory and less requirement of other processors.

- Latency is the time that represents the period when we offer an order on our device and the action happens. 5G will have 10 times the potential of 4G for real time different actions.
- With 5G, a large number of devices can be connected. All connected devices will have immediate internet admittance and be able to communicate with real-time data. It would be beneficial for the Internet of Things.
- 5G also permits the establishment of virtual networks, network slicing and subnets to provide more personalized connections.

Wireless technology is classified into various categories. In 1G wireless technology that is analog or continuous in nature. Digital data is utilized in 2G wireless communications. Global System for Mobile was also developed as a second-generation technology based on time-division multiple access systems. 3G systems are based on code-division multiple access. 4G technology features more complex technology such as video conferencing and gaming services, as well as the ability to transfer data at a very rapid rate. 5G technologies include 2G, 3G, and 4G technology, as well as the technology that supports them such as EDGE, GSM, UMTS, LTE, LTE advanced pro, etc. (Elijah, Rahman, Orikumhi, Leow, and Hindia,2018). There are numerous types of antennas are available for signal transmission as dipole, Directional, Microstrip Patch, Sector, Yagi, Parabolic, Grid, Fractal antenna, and so on.

2. LITERATURE REVIEW

In order to get a complete awareness of recent and past studies, a number of current papers on this related topic have been studied. This section provides the researcher's most recent antenna design approaches, including software and hardware designs. In today's world, there is a significant demand for high-speed data transmission. In rural places, data transmission speeds are currently very slow. A multi-input multi-output-based antenna might be an excellent solution to this problem.

Raut, Hema, Shevada, Malekar, and Kumar (2021) proposed an ultra-wideband antenna with a circular shape and inside-cut feed structure for IoT applications. This antenna is useful for the upper Ku band with compact dimensions, omnidirectional radiation pattern, and 3.94 dBi peak gain.

Balti and Johnson (2019) proposed a circularly polarized microstrip antenna structure working with frequencies 5.80 GHz and 500 MHz bandwidth. It can be reconfigured according to our

requirements. Finite difference time domain can be used for radiation pattern simulation. The propagation medium would be free space limited by perfectly matched layers and absorbing boundaries. The finite difference time domain 2D and 3D can be used in a medium including a circle or sphere of dielectric in the middle. So that both rays' incident and dispersed emf fields reflected back from the striking dielectric object. It is the best arrangement of the propagation model of the accuracy.

Yang, Sun, and Guo (2019) give a circular patch MIMO antenna with multi-polarized wide band for 5G applications. The antenna will work with bandwidth 3300 MHz -4200 MHz for access point applications. The antenna can be energized by three probe feeds which are similarly dispersed by 120^{o} to create three distinctive polarized waves in the basic transverse magnetic TM11(Transverse Magnetic) mode. Each port is encircled by a printed ring slot to accomplish good impedance matching and isolation. In his way efficiency would be greater than about 88% and 6.6dBi is peak antenna gain. Low estimated envelop relationship coefficient is obtained.

Yin, Wu, Yu, Wang and Hong, W (2019) designed E-shaped symmetrical multimode resonance antenna proposed for millimetre 5G applications. To change the E field dispersion of the TM20 mode a longitudinal space is carved on surface without influencing the TM11 mode. Etching is more beneficial to resonate with two frequencies which are very closer to each other. The proposed antenna exhibits wide bandwidth and great impedance. The antenna will work around Ka-band. The proposed antenna is incredible for 5G mm-wave applications.

Ahmed, De and Hussain (2018) proposed a great innovative model in the field of horticulture and precision farming. With the use of Wi-Fi and WiMAX-based long-distance technology using IoT, becomes very easy to controlling and monitor farming in rural areas. With this scalable network current IoT-based agriculture arrangements proposed arrangement reduced network problems up to some extent.

An, Li, Fu, Ma, Chen and Feng (2018) proposed a low-profile compact antenna with extensive bandwidth and constant radiation pattern. In all resonant modes, diverse frequencies comprise in one structure. Folded walls are used to increase bandwidth with stable gain and good impedance matching. This antenna is utilized for 5G remote communication applications with low cross-polarization and low back lobes.

Huang, Li and Liu (2018) proposed a double polarized massive multi-input multi output antenna used for 5G wireless applications with incredibly low profile. It is combination of three main components principal radiator, a donut and a reflector. The main radiator comprises of

two differentially feedlines set with rough patch on ground. To couple the feedlines feed is used with a little gap on patch, have remarkable feature than the other designs. To compensate the inductive part annulus is set over the main radiator.

Kunwar and Gautam (2017) gives fork shaped fed microstrip patch antenna for WLAN/WiMAX and Bluetooth. In this design defected ground plane is implemented with fork shape patch on ground and microstrip feedline is used. To enhance impedance matching and bandwidth T shaped ground plane is preferred with a rectangular slot. The antenna would resonate at two distinct frequencies to cover complete range for WLAN and WiMAX. The measured bandwidth of antenna is 410 MHz and 3.78 GHz for both upper and lower band respectively.

Kunwar, Gautam and Kanaujia (2017) proposed a small size antenna structure would cover different standards in a single structure. This design proposes a combination of defected ground plane with an inverted L shape patch. The antenna can be excited for three different bands 2.39 to 2.51 GHz, 3.15 to 3.91GHz, and 4.91 to 6.08 GHz. These bands cover the entire WLAN and WiMAX groups. This design provides excellent radiation pattern and integrates both applications in a single structure with compact size of dimension 20 * 30 mm ^{2}.

Kunwar, Gautam, and Rambabu (2017) proposed a compact microstrip planner antenna with low profile used for long distance WLAN and WiMAX applications. This paper presents an antenna can energized triple band activity gives good impedance bandwidth to consolidate WLAN and WIMAX both in one. The antenna arrangement is combination of U formed radiator and a defected ground plane. The size of antenna is small with dimensions 10*26 mm^2 which covers three distinct bands from 2.40-2.52 GHz,3.40-3.60 GHz 5-6 GHz that covers complete range of WLAN and WiMAX bands.

Ramachandran, Mathew, Rajan and Kesavath (2017) presented a four-port diversity tri band antenna for MIMO applications with FR4 substrate. In this design split rings are used for isolation. The structure is designed in gain of 1.6dBi for 2.4 GHZ, 3.5dBi for 3.5GHz and 4.1dBi for 5.5GHz frequency bands for covering UMTS, LTE 2300, and WiMAX bands correspondingly. The value of return loss was -27 dB, -18dB along the bandwidth of 450MHz and 480MHz for lower and middle frequency bands. The isolation achieved was 17 dB for 2.4 GHz frequency band. The size of the antenna is compact with dimension 0.26 λ * 0.26 λ* 0.01 λ with minimum isolation of 22dB between its elements.

Shah, Hayat, Khan, Alam, Ullah and Afridi (2016) proposed reconfigurable antenna with the replacement of conventional antenna, so cost and size of antenna will reduce maintaining the

required efficiency. Recently reconfigurable antennas grasp the interest of researchers for many different applications such as smart weapon protection, Unmanned Air Vehicle, Airplane, Cellular radio system, Mobile systems. So, there is huge demand of reconfigurable antennas for various applications and different frequencies 900 MHz, 2.4 GHz, 3.5 GHz. Gautam, Bisht and Kanaujia (2016) designed a defected ground structure microstrip patch antenna for WLAN and WiMAX applications. The proposed antenna would operate at specified frequencies for WLAN and WiMAX applications. In this antenna design defected ground plane is used with annular radiator encircled by rhombus strip. This design would work for both applications in single structure. The material used for manufacturing is easily accessible FR4 has advantages like compact size, good radiation pattern, and high gain for WLAN, and WiMAX applications. Elhamraoui, Abdelmounim, Zbitou, Bennis and Latrach (2018) a pentagonal-shaped planar Dual-Band Monopole antenna has been presented on FR4 GSM 1800 and Wi-Max 3.5GHz. The Return Loss values were -13dB, -15dB along with a peak gain of 0.611dBi and 3.56dBi for GSM and Wi-MAX frequency bands respectively. The Radiation Patterns were characterized by the presence of nulls across both the frequency bands under both the azimuth and the elevation planes.

Khandelwal, Kanaujia, Dwari, Kumar, and Gautam, (2015) proposed a minimized Microstrip patch Line-Fed stacked fix antenna apparatus designed for both WLAN and WiMAX. A circle is mounted on the ground plane to increase bandwidth. It would operate at two different frequency bands with reduced size of 36 %. The manufactured antenna is good arrangement for simulated and measured results and works with both applications WLAN and WiMAX.

Kumar, Gautam, kanaujia, and Rambabu (2015) worked on minimized F-formed planner antenna is proposed for remote framework can be energized with triple band WLAN, and WiMAX applications. It is comprising of two F- formed shaped of equal size are mounted on rectangular patch to perform multiband activity. A circle shape patch is used in gap to enhance impedance matching. This antenna resonates at three different frequencies with different impedance bandwidth capacities.

Mahlaoui et al. (2015), proposed Dual Band Fractal antenna on the sierpinski curve would result in resonant 2.46 GHz and 5.34 GHz frequencies. Resulted peak gains were 6.2 dB and 7dB along with the bandwidth of 0.6 GHz and 2.11 GHz for both the bands. The offered radiation pattern would be bi-directional for both the azimuth and elevation planes across both the frequency bands.

Gutiérrez, Villa-Medina, Nieto and Porta (2013) developed an automatic irrigation model for optimization of all resources used for harvests. In this system wireless sensors are placed in roots of plants to measure all parameters. An algorithm was established in which edge values are set for water level and moisture, as the value would cross the threshold value message would be sent by full duplex communication link. This system is very useful in water limited areas and cost effective also.

Haider, Caratelli, and Yarovoy (2013) examine the organization structure dependent on latency throughput and coverage range. Modern wireless systems have antennas that can be utilized for a variety of purposes. All parameters fixed and capable of performing adequately for a particular application frequency.

Christodoulou, Tawk, Lane and Erwin (2012) give reconfigurable antenna, with the capacity to radiate at various frequencies and polarizations are essential in current telecom frameworks. The prerequisites for expanded usefulness are direction finding, control, radar, and order inside a limited volume placing a greater burden on the present communicating frameworks. Reconfigurable radio antennas are an answer to this issue. This paper examines the distinctive reconfigurable parts that can be utilized in a radio antenna to modify its design and capacity. A reconfigurable antenna can be used for both terrestrial and space applications, such as MIMO, cognitive radio, and satellite communication.

Lizzi and Massa (2011) proposed a double band antenna appropriate for Long Term Evolution standard, which has been designed on an Arlon dielectric substance with 3.38 permittivity. The structure would work with 700 MHz and 2600 MHz frequency bands along -11.9 dB return loss and -37.1db receptively. Reported peak gains 5dB and 6.4 dB along with bandwidth of 131 MHz and 310 MHz for both bands. For both planes the radiation pattern would be omni directional.

Srifi, Meloui and Essaaidi (2010) designed a miniature wideband rectangular patch antenna for WLAN, WiMAX, also working with 5-6 GHz ISM band. The design of antenna is compact with dimension 20mm * 15 mm * 0.8 mm and easily accessible material FR4.The antenna will give bandwidth of 4.84-6.56 GHz for S11< -10dB. Rectangular slot and step have been used to enhance bandwidth.

Kim, Evans and Iversen (2008) develop a model for efficient water management for agriculture using graphic user interface-based software. In this model distributed field sensors offer a unique solution for maximizing the productivity and as well as saving water. In this paper complete irrigation area is divided in six field sensors stations and real time data is

collected by different distributed sensors, wirelessly transmitted to a base station. To transmit the data from sensor network to base station low-cost Bluetooth technology is used.

Wang, Zhang and Wang (2006) discussed various Wireless technologies have been going under fast increase in present era. Various types of technologies like for small range infrared light used and for long range GSM/GPRS used. Wireless sensors have many impossible applications in agricultural for monitoring and controlling various parameters in remote area. Various sensors are available in the market to collect the real time data from agricultural area such as temperature sensor, ph. value sensors, and pressure and moisture sensors.

2.1 Gaps in Literature

From the literature survey, some gaps or challenges analysed associated with wireless technology used everywhere like agriculture, medical science, and industry field-

i. For many wireless applications, a multiband antenna is in demand.
ii. For improved diversity performance in wireless applications, a high-gain antenna is necessary.
iii. A wider bandwidth and a more compact antenna design can be investigated for modern wireless applications.
iv Underutilization of the electromagnetic spectrum.
v. Antenna design must be cost-effective.

3.DESCRIPTION OF BROAD AREA

Wireless Communication:

The transmission of data over a long distance without the need of wires, cables, or other electrical appliances is known as wireless communication. Wireless communication is a broad term that encompasses all methods and procedures for connecting and communicating between two or more devices using wireless communication technologies and equipment. Wireless technologies such as IoT, infrared, Bluetooth, Wi-Fi, GPRS, WLAN, WiMAX, and others are employed. The following are the benefits of wireless communication:

- The transmitted speed is very high, the distance can range from a few meters' television remote control to a long-distance radio communication.
- Wireless communication ion used everywhere like industries, transportation, medical sciences, cell phones, home networks, king, and wireless internet access.

- Other applications of include GPS in devices, garage door openers, wireless computer mice, keyboards and headsets, headphones, radio receivers, satellite communication, broadcast television, and wireless telephones.

Different antennas have been designed and analysed for wireless applications. It is possible to accomplish so using Radio Frequency and Infrared radiation. Table 1 explains the same wireless frequency channels.

Table 1. Wireless frequency bands used for Microstrip Antenna Applications

Designation		**Frequency Limits**
VLF	very low frequency	3kHz-30 kHz
LF	low frequency	30 kHz-300 kHz
MF	medium frequency	300 kHz-3MHz
HF	high frequency	3MHz-30MHz
VHF	very high frequency	30MHz-300MHz
UHF	ultra-high frequency	300MHz-3GHz
SHF	super high frequency	3GHz-30GHz
EHF	extremely high frequency	30GHz-300GHz

Patch Antenna:

A patch antenna is a type of transducer that is made by printing a patch of conductive material over a dielectric surface such as FR-4, though many other materials can be utilized. The dielectric substance is applied to a ground plane, which serves as a foundation for the entire supporting system. The antenna is excited by a feed line linked via the patch. Feed mechanisms could use a variety of feed strategies. It is also known as a Microstrip antenna or printed antenna due to its use of microstrip technology on a printed circuit board. Patch antennas are low-profile antennas used for microwave applications with frequencies greater than 100 MHz. These antennas come in a variety of shapes, with the shape determined by the metallic patch placed on the dielectric substance. Patches might be rectangular, square, round, triangular, annular, or elliptical in shape. Assume we have a rectangle patch antenna that was constructed by sewing a rectangular metallic patch on a dielectric-coated ground plane. This indicates that a ground plane with a conducting patch supports a dielectric material. Figure 3 shows patch is etched on substrate with half wavelength and the thickness is small less than λ. Excitation to the antenna is also given through microstrip feed line linked to the patch. In this case, a dielectric substrate is employed to separate the strip from the ground plane.

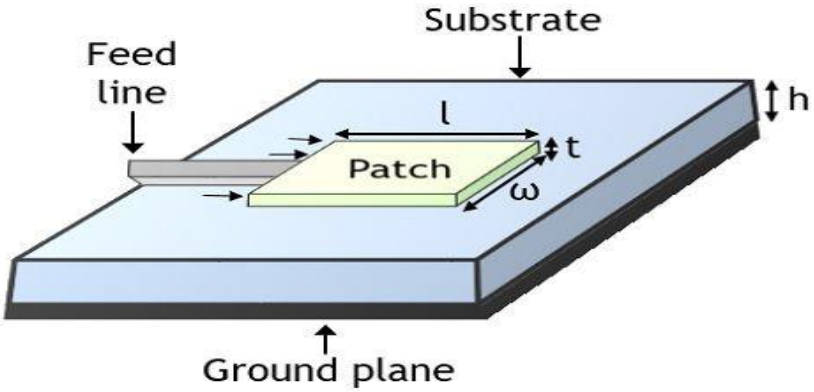

Figure 3. Microstrip Patch Antenna (Elhamraoui, Abdelmounim, Zbitou, Bennis, and Latrach, 2018.)

Patch or strip and feed lines are photo-etched on the substrate's surface. Because of their ease of manufacture, patches can be moulded into a variety of shapes. Patches with rectangular, round, or square shapes are most commonly used. Patch antennas can also be created by assembling numerous patches on a dielectric substrate. To excite the antenna, single or multiple feed lines are employed, depending on the application.

Advantages

- The antenna is compact and light in weight.
- It has a simple fabrication technique.
- Installation is simple due to the low volume and tiny dimensions.
- It allows for simple integration with various devices.
- The antenna arrays are simple to create.
- It has a high level of resilience on stiff surfaces.

Disadvantages

- The antenna has a low efficiency.
- These antennas are extremely sensitive to environmental conditions.
- They have a low power handling capability, a low gain, and a narrow bandwidth.
- These are more susceptible to erroneous feed radiation.
- Microstrip antennas have higher dielectric and conductor losses.

Patch Antenna Applications

- For wireless communications due to their low profile.
- These antennas are used as communication antennae on missiles.

- Satellite communication and microwave applications due to their compact size.
- The Global Positioning System is one of the key advantages of microstrip antennas.
- These antennas are also employed in phased array radars, which can accept a certain level of bandwidth tolerance, making it simpler to track vehicles and marines.

Wireless Communication Benefits

Transfer of information between two or many destinations without the use of a physical connection in between source and destination is known as wireless communication. Wireless communication has various advantages because there is no "physical infrastructure." This typically entails reducing distance or space. There are various advantages to wireless communication; the most important ones are described here.

- Cost-effectiveness
- Flexibility
- Convenience
- Speed
- Accessibility
- Constant connectivity

4. OBJECTIVES OF THE STUDY

A literature review reveals that the radio frequency spectrum is getting crowded due to the increased demand for wireless applications. Therefore, the Federal Communications Commission is reallocating the spectrum for various 5G Mid Band services. Recently, FCC planned to release an unlicensed sub-6GHz band with 1200 MHz bandwidth for wireless applications. Thus, various new devices with the wifi-6E label will be designed for this frequency band. An antenna is also an integral part of the newly designed wifi-6E devices. The main focus of the proposed research is to design new antenna structures that can be effectively used in wifi-6E devices for better utilization of the radio spectrum with improved radiation properties and reduced system complexity.

a. To design, analyse and validate new antenna structures for WLAN, WiMAX, and IoT applications.
b. To fabricate and analyse new antenna structures for the unlicensed sub-6GHz sub-band and 5G applications

c. To measure and compare various antenna parameters like return loss, antenna gain, bandwidth, radiation pattern for optimized design.

5. METHODOLOGY

This research consists of different literature studies for better methodology. In this methodology, all the parameters of antenna length, width, thickness, material, and suitable shape are selected for wireless applications. Implement the antenna design by using CST Studio Suite 2019 simulator for particular bandwidth which is suitable for an unlicensed sub- 6GHz band, wireless applications, and optimize all the parameters. The proposed methodology is divided into five steps for better results. During the first step main agenda is to study literature survey of microstrip antenna used for wireless applications. And then select all the parameters related to antenna design for wireless applications. Then ground plane, substrate, and patch is designed with suitable material and assign the different ports to antenna for simulation. Then verify and optimize the result and S-parameters of antenna. Figure 4 shows the flowchart of proposed methodology –

Step 1: Selection of antenna design will take place by studying the literature review of existing antennas used for wireless applications.
Step 2: Select all the parameters related to antenna-like material used for ground plane, substrate and radiation patch, height, length, width, suitable shape of patch according to application.
Step 3: Design a microstrip antenna by using CST Studio Suite Software 2019 version.

Step 4: Simulate the design and check all the parameters like S-parameters, gain, bandwidth and directivity.
Step 5: Verify results and optimize parameters of antenna for better results.

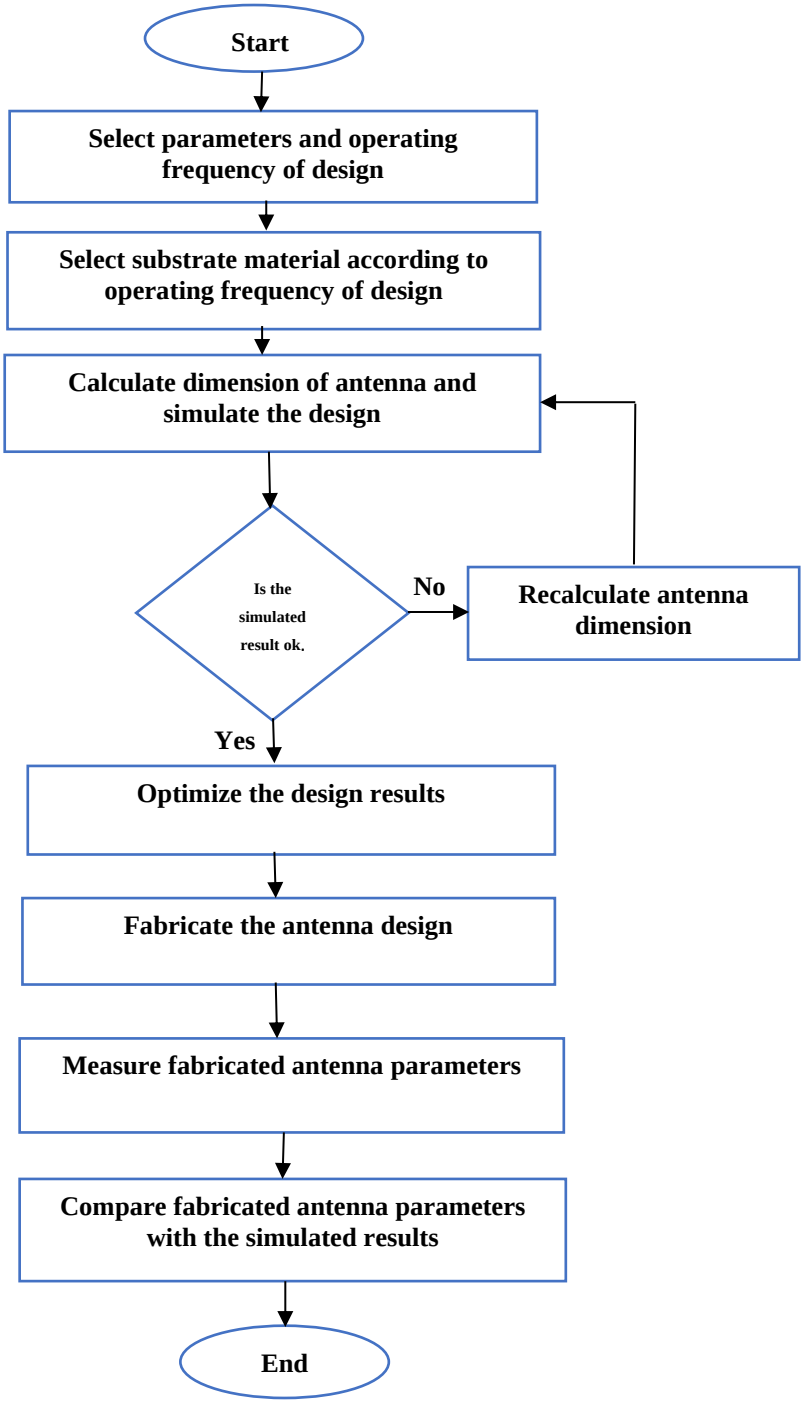
Start
Select parameters and operating frequency of design
Select substrate material according to operating frequency of design
Calculate dimension of antenna and simulate the design
Is the simulated result ok.
No
Recalculate antenna dimension
Yes
Optimize the design results
Fabricate the antenna design
Measure fabricated antenna parameters
Compare fabricated antenna parameters with the simulated results
End

Figure 4. Flow Chart of Methodology for Antenna Design

6. EXPECTED OUTCOME OF RESEARCH

Some new antenna structures will design develop and analyse for wifi-6E wireless devices that can be used for various wireless applications. Proposed antennas are for multiple bands,

improved gain, directivity, and improved bandwidth and are compatible with the new spectrum launched by Federal Communications Commission for wireless applications.

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DESIGN AND ANALYSIS OF PLANAR MICROSTRIP ANTENNAS FOR 5G AND IoT APPLICATIONS

SHORT SYNOPSIS

by

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19/Ph.D./115

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ABSTRACT

The evolution of Fifth-Generation (5G) networks is readily available as the main driver of the growth of the Internet of Things (IoT) applications. The Internet of Things is a new idea that interconnected gadgets for variety of applications, including communication, transportation, medical science, education, and commercial progress.

The most critical element of constantly developing wireless technology is an antenna and planar antennas are typically preferred in wireless applications due to their uniformity to planar and non-planar surfaces, ease of fabrication utilizing existing printed circuit technologies, mechanical toughness when mounted on stiff surfaces, and compatibility with Microwave Monolithic integrated circuits designs. Wireless communication is exploring every aspect, so the radio frequency spectrum is getting crowded due to the increasing demand for wireless applications. Furthermore, all modern future fifth-generation wireless systems require the integration of short-range transceivers such as Sub-6GHz, Sub-7GHz, WiFi-6, and WiFi-6E in a single computing device. This scenario has created a demand for 5G antennas for wireless networks. So, the requirement to develop antennas with high gain,

and wide bandwidth for wireless 5G transmission. Therefore, Federal Communications Commission is reallocating the spectrum for various wireless applications.

The main focus of this work is to design and develop 5G antennas that can handle several wireless protocols with higher bandwidth to meet future 5G applications. Various defective ground structures, parasitic patches, meandering edges, electromagnetic band gap structures, and notches will be added to the framework to decrease the dimensions. Various antenna performance parameters such as s-parameters, voltage standing wave ratio, Radiation, Beamwidth, Gain, and so on must be recorded and studied using an antenna simulation program.

Keywords: Internet of Things (IoT), Fifth Generation (5G), Wireless Local Area Network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), Multi-input multi-output (MIMO).

DESIGN AND ANALYSIS OF PLANAR MICROSTRIP ANTENNAS FOR 5G AND IoT APPLICATIONS

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